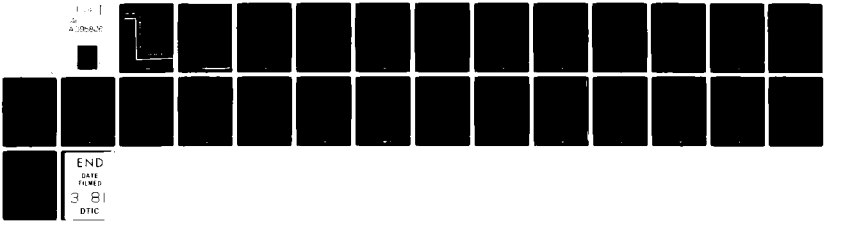
AD-A095 826 AIR FORCE HUMAN RESOURCES LAB BROOKS AFB TX F/G 5/1
SKILLS MAINTENANCE AND REACQUISITION TRAINING RESEARCH PROGRAM:--ETC(U)
MAR 81 E E EDDOWES, J C DEMAIO, B J PIERCE
UNCLASSIFIED AFHRL-TR-80-45 NL



END
DATE FILMED
3-81
DTIC

AFHRL-TR-80-45

AIR FORCE HUMAN RESOURCES LABORATORY

AD A095826

DDC FILE COPY

SKILLS MAINTENANCE AND REACQUISITION TRAINING RESEARCH PROGRAM: TACTICAL AIR COMMAND PRELIMINARY EVALUATION

By

Edward E. Eddowes
Joseph C. DeMaio
Byron J. Pierce

OPERATIONS TRAINING DIVISION
Williams Air Force Base, Arizona 85224

James L. Eubanks
Don R. Lyon
Thomas H. Killion
Robert T. Nullmeyer
University of Dayton Research Institute
300 College Park Avenue
Dayton, Ohio 45469

March 1981
Interim Report for Period February 1978 — November 1979

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

NOTICE

When U.S. Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This interim report was submitted by the Opeations Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224, under Project 1123, with HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235. Edward E. Eddowes was the Principal Investigator for the Laboratory.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

MARTY R. ROCKWAY, Technical Director
Operations Training Division

RONALD W. TERRY, Colonel, USAF
Commander

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AFHRL-TR-80-45	2. GOVT ACCESSION NO.: AD-A095 826
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): SKILLS MAINTENANCE AND REACQUISITION TRAINING RESEARCH PROGRAM: TACTICAL AIR COMMAND PRELIMINARY EVALUATION	5. TYPE OF REPORT & PERIOD COVERED: Interim rept. Feb 1978 – Nov 1979
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Edward E. Eddowes, Joseph C. DeMaio, Byron J. Pierce, James L. Eubanks, Don R. Lyon, Thomas H. Killion, Robert J. Nullmeyer	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Operations Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 62205F, 11230236
11. CONTROLLING OFFICE NAME AND ADDRESS: HQ Air Force Human Resources Laboratory, Brooks Air Force Base, Texas 78235	12. REPORT DATE: March 1981
	13. NUMBER OF PAGES: 28
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

critical flying skills
Air Force continuation training
skill measurement
flying skill analysis
individualized flying training
flying training

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this study was to determine if flying skills could be identified, defined, and measured. It was part of a program to develop quantitative, objective procedures for the efficient management of aircrew training.

Fighter pilots were interviewed to select sample tasks, specify pilot actions required to perform them, and identify and define the skills involved in their performance. Analyses of the pop-up weapons delivery and low altitude tactical formation tasks identified six skills: planning, recheck, discriminating, anticipating, deciding, and controlling. Skill measurement procedures in which pilots rated their bombing and formation flying performance were developed. Skill ratings were collected to evaluate the measurement procedures.

DD FORM 1 JAN 73 1473

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

404415

Item 20 (Continued)

Contingency chi square analyses disclosed significant relationships between skill ratings and bomb scores. Multiple regression analyses of formation ratings indicated that position keeping and visual lookout were significant components of formation performance.

The validity and generalizability of pop-up and low altitude tactical formation skill measurement techniques were investigated in a subsequent operational test using aircrew personnel of five fighter wings. Data from this evaluation confirmed the findings of the earlier measurement development efforts. These results were interpreted as evidence of the validity of the skill measurement approach.

PREFACE

This report documents the planning and management of the Air Force Skills and Maintenance and Reacquisition Training Research Program (Project SMART).

This research was conducted under Project 1123, USAF Flying Training Development, James F. Smith, project scientist; Task 112302, Flying Training Innovations, Dr. Bernell J. Edwards, task scientist; Work Unit 11230236, Skills Maintenance and Reacquisition Training (Project SMART). Dr. Edward E. Eddowes, principal investigator.

The goals of this project are to develop and validate comprehensive, quantitative, and objective procedures which will permit the Air Force to manage an individualized flying training program that will provide acceptable mission readiness at minimum cost. This effort validates previously developed measures of skills involved in the pop-up weapons delivery and low altitude tactical formation tasks and provides evidence of the validity of the skills measurement approach toward optimizing pilot mission readiness.

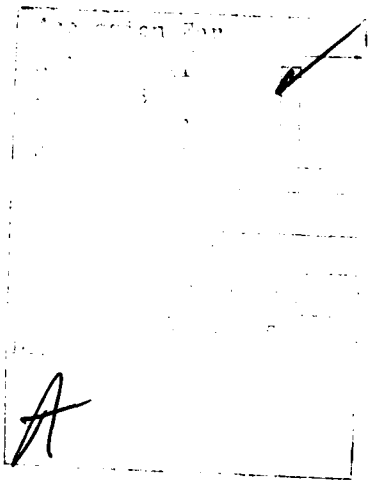


TABLE OF CONTENTS

SKILLS MAINTENANCE AND REACQUISITION TRAINING RESEARCH PROGRAM: TACTICAL AIR COMMAND PRELIMINARY EVALUATION

I. INTRODUCTION

The Skills Maintenance and Reacquisition Training research program (Project SMART) is based on a priority Air Force (USAF/XOOT) research requirement to identify and define critical combat skills of mission-ready aircrews and to develop a user-oriented technology for measuring these skills. Project SMART research will generate the quantitative data needed to determine how frequently critical flying skills must be practiced to optimize pilot mission readiness. The objective of Project SMART is to develop and validate comprehensive, quantitative, objective procedures for the efficient management of individualized flying training which will provide aircrew mission readiness at minimum cost. The objectives of the Project SMART Tactical Air Command (TAC) Preliminary Evaluation were (a) to provide an early evaluation of the key concepts and methods of all phases of the program, (b) to identify and define selected critical flying skills, (c) to develop procedures for measuring these skills, and (d) to evaluate and refine the skill measures.

II. TECHNICAL APPROACH

Previous efforts to improve flying training have focuses on task requirements. Project SMART, however, focuses on identifying, defining, and developing procedures for measuring the critical skills underlying aircrew mission readiness. Research reported by Meyer, Laveson, Weissman, and Eddowes (1974) and by Meyer, Laveson, Pape, and Edwards (1978) indicates that a small, manageable number of skills can be identified and defined which cut across the range of task performances that are required of mission-ready TAC aircrews.

Given operationally oriented definitions of aircrew mission-ready skills, along with feasible, meaningful and acceptable aircrew skill measurement techniques, proficiency levels on each critical skill can be determined and relevant practice can be prescribed as required to bring such skill deficiencies as are detected up to mission-ready criterion levels. Consequently, the contents of each sortie flown can be justified by and specified on the basis of diagnostic information provided by the skill measurment procedures.

Previous research systematically addressing Air Force continuation training has been minimal. Therefore, Project SMART was initiated with a preliminary evaluation study designed to develop skill definition and measurement procedures based on study of a small sample of critical flying tasks. During the first 7 months of the TAC preliminary evaluation, research efforts were aimed at developing, evaluating, and refining skill measurement procedures designed to assess pilot skills exercised in accomplishing the pop-up weapons delivery (pop-up) and the low altitude tactical formation (LATF) tasks. These measurement procedures were developed in coordination with a mission-ready A-7 squadron and an F-4 combat crew training squadron through a series of iterative refinements based on pilot self-assessment records collected during the flying training operations of these two squadrons.

Following presentation of the mid-term progress report on the TAC Project SMART Preliminary Evaluation at HQ TAC on 6 October 1978, it was suggested that these skill measurement procedures be validated. Consequently, a TAC-wide test of skill measurement procedures for the pop-up and LATF tasks was designed and implemented during January and February 1979.

III. METHOD

Participants. Pilots who contributed to the results of the Preliminary Evaluation included those of the 354th Tactical Fighter Squadron (TFS), Davis-Monthan AFB; the 311th Tactical Fighter Training Squadron (TFTS), Luke AFB; the 4th Tactical Fighter Wing (TFW), Seymour Johnson AFB; the 23rd TFW, England AFB; the 347th TFW, Moody AFB; the 354th TFW, Myrtle Beach AFB; and the 474th TFW, Nellis AFB.

Materials. Research materials consisted of the LATF and the pop-up self-assessment forms. Copies of the pop-up and LATF forms are shown in Appendix A.

Procedures. The TAC preliminary evaluation was initiated with the cooperation and participation of the 345th TFS, Davis-Monthan AFB. Semistructured interviews with eight fighter pilots of the 354th TFS were recorded and analyzed. Initial interviews were conducted to identify the critical tasks involved in fighter mission scenarios. Having identified the critical tasks to be studied, the research pilots analyzed each task into its real-time components and described the behavioral actions required to perform each component. These interviews used generalized maneuver patterns as guidelines. Pilots were interviewed both individually and in groups.

Critical task breakdown summaries were constructed using the data obtained from these interviews. The summaries were reviewed and refined in further interviews to obtain a consensus on their completeness and accuracy. In addition to the original research pilots, interviews to review the task breakdown summaries were conducted with members of the 4444th Operations Squadron (Operational Training Development), Davis-Monthan AFB, and with the staff of the Fighter Weapons School, 162nd Tactical Fighter Training Group (TFTG), Arizona Air National Guard.

Subsequent interviews focused on validation of the skill identification/definition analyses. Interviews were supplemented by photographing A-7 pop-up weapons delivery maneuvers at the Gila Bend Gunnery Range to provide additional data on available means for skill measurement. Many of these pop-up passes were supplemented by audio recordings of pilot commentary during the maneuver. These data served as the basis for development of practical techniques for assessing the critical flying skills identified in the analyses of the pop-up and LATF tasks. Once developed, the skill measurement procedures were used in routine flying operations to collect data to use in evaluating and revising them.

IV. RESULTS

Identification and Definition of Critical Tactical Flying Skills. Following completion of the analyses of the pop-up and LATF tasks, the tactical taxonomy of Meyer et al. (1978) was used to identify the flying skills exercised at each point during the pop-up maneuver and in accomplishing the major performance requirements in the case of the LATF task. The skill identified and their definitions were reviewed and refined through coordination with participating pilots of the 354th TFS and the 162nd TFTG.

Initially six skills were found to accommodate the performance requirements of the pop-up and LATF tasks: Planning, Recheck, Discriminating, Anticipating, Deciding, and Controlling. Their brief definitions are shown below:

Planning	— Describing and updating mission requirements.
Recheck	— Repetitive seeking and filtering of information from within and outside the cockpit.

Discriminating	— Evaluating fine differences among cues/cue patterns.
Anticipating	— Predicting what aircraft control actions will be required.
Deciding	— Selecting from among alternative aircraft control actions.
Controlling	— Achieving and maintaining a series of aircraft system and subsystem states.

The analyses of the pop-up and LATF tasks which were developed to support the identification and definition of these critical flying skills are presented in Appendix B.

Pop-Up Measurement Development. Analysis of the pop-up disclosed that the maneuver consisted of a sequence of pilot actions required to control the aircraft to a point in space from which a bomb could be released so as to hit the intended target. The initial analysis was summarized by stage of the maneuver, and the major skills exercised during each stage were identified. A self-assessment form was developed on which pilots rated their performance on each stage of the pop-up thus permitting specification of the skills involved. Preliminary evaluation research continued with collection of pop-up weapons delivery skill data for use in refining and revising the self-assessment procedures and forms. Bombing skill data were required using revised versions of the pilot self-assessment form for pop-up maneuvers flown on both tactical and controlled ranges. The pop-up self-assessment data were processed and the resulting skill scores were analyzed to determine their relationship with bomb impact scores. In addition, means for processing the bombing skill data for easy, rapid interpretation by training managers were explored.

Pop-up data were collected systematically in a study using F-4 (CCT) B-course students of the 311th TFTS. In this case, the evaluation forms were completed by instructor pilots (IPs). Analyses of the data confirmed the validity of the measurement techniques. Another similar evaluation was performed subsequently at the request of the 311th TFTS. Summary reports of these studies are presented in Appendix C.

LATF Measurement Development. The analysis of low altitude tactical formation indicated that this task involved the continuous performance of four major components, formation position keeping, low altitude flying, mutual support (visual lookout), and navigation. Further analysis of the component performances led to identification of the major skills involved. A self-assessment form for recording pilot ratings of performance on the LATF components provided for measurement of skills in the same manner employed with the pop-up. Skill measurement data generated through the use of the pilot self-assessment forms were studied in a series of multiple regression analyses to provide the basis for revision and refinement of the skill measurement materials and procedures.

LATF data were collected from pilots of the 354th TFS and subsequently evaluated to determine the utility of the skill measurement procedures for the LATF task. A report was prepared documenting the successful application of the LATF measurement procedure and the kinds of information it generated. A summary of this report is presented in Appendix D.

TAC-Wide Tests. The pop-up and LATF skill measurment materials and procedures were tested further during a TAC-wide test. Five tactical fighter wings participated in the test, the 4th, 23rd, 354th, 347th, and 474th.

During the TAC-wide test, a total of 1227 pop-up and LATF forms were collected from participating pilots. An analysis of these data demonstrated the validity of the measurement procedures and their generalizability in applications with A-10 and F-4 aircrew personnel. A summary report of the TAC-wide test focusing on an analysis of pop-up data is presented in Appendix E.

V. CONCLUSION

These findings indicate that Project SMART has developed a methodology for identifying, defining, and measuring critical tactical fighter tasks across aircraft systems. In addition, the methodology is also successful in identifying critical subtasks: a finding that can have substantial diagnostic value for training managers in specifying priority training requirements.

The present results, however, are not the end product of Project SMART. They provide a substantial baseline of proven research procedures and a data base to support and stimulate further evaluation and refinement of Project SMART objectives and techniques. During the next phase of the research program, critical air combat maneuvering and air-to-ground attack skills not studied in Phase I will be identified and defined and procedures for their measurement developed and validated.

REFERENCES

DeMaio, J.C., & Eddowes, E.E. *Airborne performance measurement assessment: Low altitude tactical formation in two operating environments.* AFHRL-TR-79-44, AD-A087 068. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, February 1980.

Lyon, D.R., Eubanks, J.L., Killion, T.H., Nullmeyer, R.T., & Eddowes, E.E. *Pop-up weapon delivery maneuver. Use of pilot self-assessment data in analysis of critical components.* AFHRL-TR-80-33. Williams AFB, AZ: Operations Training Division, Air Force Human Resources Laboratory, October 1980.

Meyer, R.P., Laveson, J.I., Weissman, N.S., & Eddowes, E.E. *Behavioral taxonomy of undergraduate pilot training tasks and skills: Executive summary.* AFHRL-TR-74-33(I), AD-A008 771. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, December 1974.

Meyer, R.P., Laveson, J.I., Pape, G.L., & Ewards, B.J. *Development and application of a task taxonomy for tactical flying.* AFHRL-TR-78-42 (Vol. I, AD-A061 387; Vol II, AD-A061 388; Vol III, AD-A061 478). Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, September 1978.

Pierce, B.J., DeMaio, J.C., Eddowes, E.E., & Yates, D. *Airborne performance measurement methodology application and validation: F-4 pop-up training evaluation.* AFHRL-TR-79-7, AD-A072 611. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, June 1979.

Pierce, B.J., DeMaio, J.C., & Yates, D. *Validation of an in-flight measurement methodology: F-4 ground attack training evaluation.* Paper presented at the annual meeting of the Human Factors Society, Boston, October 1979.

APPENDIX A: POP-UP AND LATF SELF-ASSESSMENT FORMS

POP-UP EVALUATION FORM

PILOT #: _____ Squadron #: _____ RANGE #: _____ _____

EVENT: _____ BLOCK: _____ DATE: _____

PASS #

	1st	2nd	3rd	4th	
BOMB SCORES	___	___	___	___	
Task Evaluation					COMMENTS/INDICATE Pass #
1. Approach to PUP*	___	___	___	___	_____
2. PUP	___	___	___	___	_____
3. Climb Leg	___	___	___	___	_____
4. Target Acquisition	___	___	___	___	_____
5. Pull Down Point	___	___	___	___	_____
6. Apex	___	___	___	___	_____
7. Track Point	___	___	___	___	_____
8. Bomb Run	___	___	___	___	_____
9. Recovery	___	___	___	___	_____
10. Rtn to Low Level	___	___	___	___	_____

Legend: E — Excellent S — Satisfactory M — Marginal U — Unsatisfactory
*PUP — pop-up point

INSTRUCTIONS

1. COMPLETE THE PILOT IDENTIFICATION PORTION OF THE FORM

2. RECORD BOMB SCORES.

3. GRADE THE TASK EVALUATION SECTION AS FOLLOWS:

   E — Excellent. Task performance met criteria with no error reflecting an unusually high degree of ability; no compensations were required.

   S — Satisfactory. Task performance met criteria with minimal error; minimal compensation were required.

   M — Marginal. Task performance met criteria with error; compensations were required to salvage the pass delivery.

   U — Unsatisfactory. Task performance did not meet criteria; gross errors in performance led to either an unsafe or aborted pass.

Task evaluations are to be based on 1) proficiency to maneuver the aircraft, 2) situation awareness, 3) agressiveness and 4) survivability. Any item graded as either M or U requires an appropriate explanation under the Comments section.

The following indicates those requirements identified with each item included in the Task Evaluation section:

1. Approach to PUP: (a) Acquisition of PUP; (b) Altitude control; (c) Airspeed control; and (d) Heading control.

2. PUP: (a) Heading correction; (b) "G" applications; (c) Airspeed correction; and (d) timing/ distance error.

3. Climb Leg: (a) Climb angle corrections; and (b) airspeed corrections.

4. Target Acquisition: Self-explanatory

5. Pull Down Point: (a) Roll; (b) Airspeed corrections; (c) "G" application; and (d) Altitude/position control.

6. Apex: (a) Pattern/position correction; and (b) Airspeed corrections.

7. Track Point: (a) Aim off point; (b) Roll out; (c) Initial wind correction; (d) Angle, azimuth, and position checks; and (e) Initial pipper placement.

8. Bomb Run: (a) Aiming error corrections; (b) Airspeed control; (c) Exposure time control; and (d) Altitude, azimuth, and dive angle corrections.

9. Recovery: (a) "G" application; (b) Jinking; and (c) Altitude and timing control.

10. Return to Low Level: (a) Exposure time; and (b) Transition to low level.

LATF Individual Performance Evaluation

Pilot number_____ Date_____ Call Sign_____

1.	Visual Lookout	N/A	U		M			S		E
		X	0	1	2	3	4	5	6	7
2.	Maintaining Position:									
	a. Your performance	N/A	U		M			S		E
		X	0	1	2	3	4	5	6	7
	b. Element member's performance:	N/A	U		M			S		E
		X	0	1	2	3	4	5	6	7
3.	Rate your all around performance during each mission segment below:									
	a. Takeoff and join-up:		U		M			S		E
			0	1	2	3	4	5	6	7
	b. Target Ingress:		U		M			S		E
			0	1	2	3	4	5	6	7
	c. Time on target:	N/A	U		M			S		E
		X	0	1	2	3	4	5	6	7
	d. Rejoin and/or egress:		U		M			S		E
			0	1	2	3	4	5	6	7
	e. Recovery:	N/A	U		M			S		E
		X	0	1	2	3	4	5	6	7
4.	Give Comfor level: CL_____ Ft AGL.									
5.	Comfort Level Rating:		U		M			S		E
			0	1	2	3	4	5	6	7
6.	Overall Mission Performance Rating:		U		M			S		E
			0	1	2	3	4	5	6	7
7.	Familiarity with element member:		Unfamiliar							Very Familiar
			0	1	2	3	4	5	6	7

Legend: U—Unsatisfactory M—Marginal S—Satisfactory E—Excellent

LATF Individual Performance Evaluations

DIRECTIONS

For the mission just completed, rate each of the following skill areas from 0 to 7. Assign a rating of 0 to Unsatisfactory performance. Assign a rating of 7 to Excellent performance.

Definitions of Ratings

Excellent: A rating of excellent means that the task or segment was performed without error and that no corrective actions were required.

Satisfactory: A rating of satisfactory means that the task or segment was performed with minimal error and that only minor corrective actions were taken.

Marginal: A rating of marginal means that the task or segment was performed with error and that corrective actions were required.

Unsatisfactory: A rating of unsatisfactory means that the task or segment was performed with large or frequent errors and that major corrective actions were required.

Skill Areas

1. **Visual Lookout:** How adequate was the amount of time you spent clearing the area for aerial threats?

2. **Maintaining position:** How well did you (your element member) maintain position? Did you(he) signal your(his) intentions clearly and respond to signals appropriately?

3. **Mission Segments:** Rate your all-around performance on each segment below. Consider all factors relevant to each segment.

4/5. **Comfort Level:** CL is the lowest altitude at which you can detect the enemy threat and perform a defensive reaction requiring intense manuvering. Give your opinion of your CL on this mission in FT AGL and rate the adequacy of your CL to mission requirements.

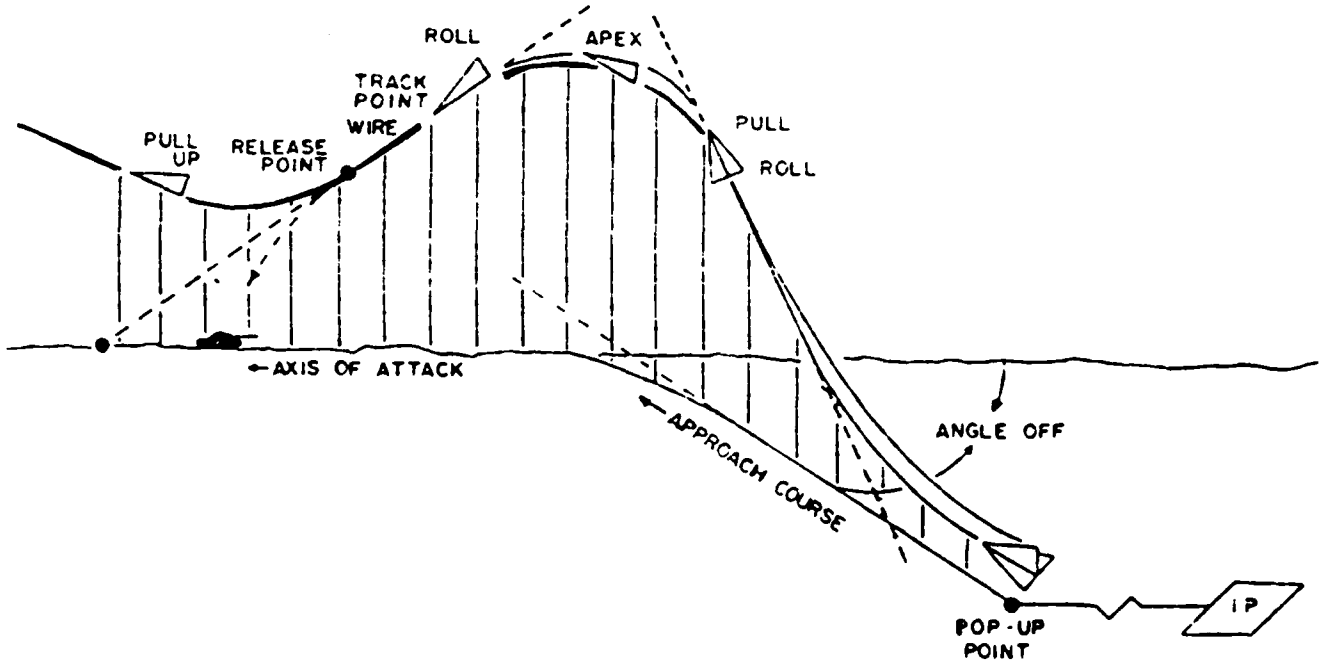
6. **Overall Rating:** Rate the quality of your performance on all phases of the mission as a whole.

7. **Familiarity:** Compared to what you consider optimum, rate the amount of experience you have had flying with your element member.

Comments: (Optional)

APPENDIX B: IDENTIFICATION AND DEFINITION OF CRITICAL SKILLS INVOLVED IN PERFORMING THE POP-UP AND LATF TASKS

Pop-Up Weapon Delivery Profile



Pop-Up Weapon Delivery Skill Identification

Sequence of Pilot Actions	Critical Skills					
	Planning	Recheck	Discriminating	Anticipating	Deciding	Controlling
			— Before Initial Point —			
Identify initial point		X	X			
Check heading					X	
Set armament switches			X			X
Review attack parameters	X			X		
Review heading change	X			X		
Prepare to hack the clock			X	X		
Review defensive formation over target	X			X		
Review change of formation at initial point	X			X		
Check inertial guidance system		X			X	

Pop-Up Weapon Delivery
Skill Identification (*Continued*)

Sequence of Pilot Actions	Critical Skills					
	Planning	*Recheck*	*Discriminating*	*Anticipating*	*Deciding*	*Controlling*
— At Initial Point —						
Turn to preplanned heading		X				X
Make preplanned airspeed change		X				X
Make preplanned tactical formation change	X				X	X
Hack clock			X			X
Check, heading, airspeed, tactics, navigation		X				
Review defensive tactics	X			X		
Activate master arms switch		X	X			X
Mentally review pop-up point (PUP), PUP parameters	X			X		
Check terrain appearance vs. plan expectations		X	X	X		
Review mental picture of target area				X		
Review formation position	X	X				
Check airspeed, clock inertial		X		X		
Anticipate pull-up				X		
Check time		X				
Acquire PUP			X			
— At Pop-Up Point —						
Go to full power at PUP		X				X
Pull back on stick		X				X
Monitor climb angle		X				
Set a climb angle		X	X			X
Check for threats			X			
Look for target (area correlate)		X	X	X		
Check altitude		X	X			
Anticipate pull down				X		
Visualize track point	X			X		
Recognize deviations from planned parameters				X		
Analyze available turning room		X				X
Continue attack, reposition to acquire target or abort attack						X
Roll in/pull down		X				X
Fly aircraft to track point					X	X

Pop-Up Weapon Delivery
Skill Identification (*Continued*)

Sequence of Pilot Actions	Critical Skills					
	Planning	Recheck	Discriminating	Anticipating	Deciding	Controlling
		— At Track Point —				
Roll out at track point						X
Fly the wire		X				X
Acquire target now or abort		X	X		X	
Recognize preplanned release parameters					X	
Maneuver aircraft to put pipper on target		X			X	X
Designate when pipper is *on* target			X		X	
Pickle (release bomb)					X	X
		— At Release Point —				
Turn, look, dive to egress target		X		X	X	X
Check for threats		X			X	
Check energy level		X			X	
Establish flight integrity			X		X	
Maintain mutual support on egress		X			X	
Egress to rendezvous point if separated from formation		X		X		
		— Exit Target Area —				

Critical Pop-Up Skills

Task Phase	Planning	Recheck	Discriminating	Anticipating	Deciding	Controlling
Before initial point	X			X		
At initial point		X		X		X
At PUP		X	X		X	X
Turn toward target		X	X	X	X	X
At track point			X		X	X
At release point	X			X	X	
Exit target area	X	X				

LOW ALTITUDE TACTICAL FORMATION
DEFINITION OF TASK REQUIREMENT

FLYING AT LOW ALTITUDE	A PILOT MUST BE ABLE TO FLY IN FORMATION COMFORTABLY AND SAFELY AT ALTITUDES BETWEEN 300 AND 100 FEET AGL.
COORDINATION OF FORMATION TASKS	MEMBERS OF A TACTICAL FORMATION MUST MAINTAIN POSITION TO PERMIT MUTUAL SUPPORT DURING AN ATTACK AND IN THE EVENT OF A THREAT TO THE FLIGHT.
MUTUAL SUPPORT	SEARCHING AN AREA BEHIND AND ABEAM OF ONE'S ELEMENT MEMBER MUST BE PERFORMED WITHOUT COMPROMISING LOW ALTITUDE FLYING OR POSITION IN FORMATION.
NAVIGATION TO/FROM TARGET	MEMBERS OF A FLIGHT MUST FOLLOW AND UPDATE THE NAVIGATION PLAN TO DELIVER A SUCCESSFUL ATTACK AT THE DESIGNATED TIME AND TO RETURN TO BASE SAFELY.

Low Altitude Tactical Formation
Skill Identification

Formation Task Requirements	Critical Skills					
	Planning	Recheck	Discriminating	Anticipating	Deciding	Controlling
Flying at low altitude		X	X	X	X	X
Coordination of formation tasks	X	X	X	X	X	X
Mutual support		X	X		X	
Navigation to/from target	X	X		X	X	

MEASURES OF LOW ALTITUDE TACTICAL FORMATION SKILL

— COMFORT LEVEL (CL):

LOWEST LEVEL AT WHICH PILOT/FIGHTING UNIT CAN DETECT AN ENEMY THREAT AND PERFORM A DEFENSIVE REACTION REQUIRING INTENSE MANEUVERING

— MINIMUM ALTITUDE CAPABILITY (MAC):

LOWEST ALTITUDE AT WHICH A PILOT/FIGHTING UNIT CAN FLY FOR BRIEF PERIODS TO NEGATE A THREAT FOLLOWING DETECTION BY ENEMY.

— TACTICAL COORDINATION

PLANNING, COORDINATING AND EXECUTING APPROPRIATE FORMATION TACTICS.

— MUTUAL SUPPORT

PROPORTION OF SIMULATED AIR ATTACKS ON FORMATION DETECTED.

— NAVIGATION

ACCURACY OF NAVIGATION TO AND FROM TARGET.

APPENDIX C: SUMMARY REPORT: AIR-TO-SURFACE WEAPON DELIVERY SELF-ASSESSMENT EVALUATION STUDY

Pierce, B.J., DeMaio, J., Eddowes, E.E., & Yates, D. ***Airborne performance measurement methodology application and validation: F-4 pop-up training evaluation.*** **AFHRL-TR-79-7. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, April 1979.**

Objective

The purpose of this study was to develop a system for evaluating performance on the pop-up weapons delivery. The performance evaluation system was intended to be applicable to a wide variety of flying environments and to be usable on several types of air-to-surface fighter aircraft systems. Specific objectives of the study were to assess the validity and applicability of the performance measurement system.

Approach

The study was begun by interviewing mission-ready pilots. The data from these interviews were used to construct a rating form for evaluation of performance on the pop-up. On this form, the pop-up maneuver was segmented into a sequence of critical stages. Each stage was associated with the skills required to support the performance of that stage. Pilot skill levels were inferred from the performance data. Bomb score data were also obtained for use in assessing the validity of the scoring system.

Background

The present research is a part of the first phase of the Air Force Skills Maintenance and Reacquisition Training research program (Project SMART). This effort is aimed at defining flying skills critical to mission readiness and developing procedures to assess these skills. Skill data will be used to aid in increasing the efficiency of Air Force continuation training programs.

The pop-up weapons delivery was the first maneuver selected for study. Proficiency at this maneuver is critical to mission readiness, and the maneuver taps several areas of flying skill. In order to perform the pop-up, a pilot needs to be proficient at low altitude flight and navigation, instrument cross-check, and basic fighter maneuvering, as well as basic bombing.

Specifics

The pop-up performance rating form incorporated a nine (controlled range sorties) or ten (tactical range sorties) stage segmentation of the maneuver. Each stage was rated on a three-point scale (Satisfactory — Marginal — Unsatisfactory). Explanatory comments were required when performance on a stage was rated than satisfactory. Detailed instructions on use of the form were provided.

The subjects were 21 F-4 B-course pilots assigned to the 311th Tactical Fighter Training Squadron, Luke AFB. The subjects were undergraduate pilot training graduates and had completed fighter lead-in training. All had completed the ground attack phase of training, but none had previously performed the pop-up weapons delivery maneuver.

Performance ratings were made by intructor pilots (IPs). Following each sortie, the IP completed the pop-up weapon delivery performance evaluation form from notes taken during the flight.

Results

Data were obtained on six ground attack tactical sorties (GAT 1 through GAT 6). The first three sorties (GAT 1 through GAT 3) were performed on controlled ranges. The last three sorties (GAT 4 through GAT 6) were performed on tactical ranges. Data were collected on all GAT sorties for every pilot.

In order to validate the performance rating system, a composite score was calculated for each pop-up weapon delivery. Under this system, the stages were examined in sequence. One point was given for each satisfactory stage rating. A marginal stage was given no point. Scoring of the pass was terminated at the first unsatisfactory stage, and only stages preceding that stage were counted toward the composite score. The range of composite scores was zero to nine (controlled range) or ten (tactical range). Composite score was used to predict the bomb score category into which the delivery would fall. Bomb scores categories were 0 to 49 feet, 50 to 99 feet, 100 to 149 feet, 150 to 199 feet, 200 to 299 feet, 300+ feet, and aborted pass. The composite rating score and the bomb score were found to be strongly related (chi-square contingency coefficient = .66, $p < .001$). This result demonstrated the validity of the rating system.

An analysis of the stages within each pass was accomplished by computing the group percentage of satisfactory ratings given on each stage. This analysis indicated that pilots found difficulty with several of the stages of the pop-up weapon delivery. The results of the present study suggested the following:

1. Subjective ratings provide a valid and reliable measure of pilot performance. This was shown by the high contingency coefficient obtained between the composite rating score and bomb score.

2. Ratings provide information on performance of the individual stages of the delivery which is not available from overall objective performance measures, such as bomb score. This assessment of stage performance levels permits inferences to be made about the overall effectiveness of training programs. Stage performances reflect the amount of training emphasis given to certain flying skill areas. By identifying skill area proficiency levels, training programs can be modified to meet the performance standards required for mission readiness.

Pierce, B.J., DeMaio, J.C., & Yates, D. *Validation of an in-flight performance measurement methodology: F-4 ground attack training evaluation.* Paper presented at the annual meeting of the Human Factors Society, Boxton, October 1979.

Background

Fighter pilot training evaluations have traditionally been based on subjective instructor pilot (IP) analysis of overall performances. In addition, during the bombing phases of fighter training programs, criteria have been established using bombing circular error for event qualification. Although these measures are indicative of overall performance, they do not provide detailed information necessary for complete performance evaluation. What is required is a performance measurement system which can be used to provide fine grain information about pilot performance on each stage of a particular maneuver. In the present study, detailed information about bombing performance was obtained by dividing the conventional weapon delivery maneuver into a sequence of stages, each of which could be rated by an instructor pilot.

Approach

At the start of the research, extensive interviews were conducted with mission ready pilots to identify and define the critical performance requirements for conventional deliveries. Discrete stages of the delivery critical to overall performance were identified. Since means for determining the values of weapon delivery parameters were not avilable for use in evaluating airborne performance, a performance measurment methodology was developed which took advantage of the IPs' ability to assess performance on the critical stages of the delivery.

Eight F-4 B-course pilots assigned to the 311th Tactical Fighter Training Squadron, Luke AFB, AZ, served as subjects. The B-course pilots are undergraduate pilot training graduates who have completed fighter lead-in training but have not been qualified in any other aircraft. At the time the study was conducted, subjects were ready to begin ground attack (GA) training. Four weapon delivery maneuvers were taught; 10 degree low angle bomb, 20 degree low angle/low drag bomb, 30 degree dive bomb, and 45 degree dive bomb. The number of deliveries performed for each maneuver varied to match the pilots' need for practice. In no case were more than four maneuvers performed on one sortie. Generally, each pilot performed 12 deliveries on each sortie.

Pilot performance ratings were collected using the F-4 GA Phase Evaluation form. The form segmented the delivery into six critical stages, (1) baseleg positioning, (2) roll-in, (3) roll-out, (4) pipper placement, (5) bomb run, and (6) recovery. The baseleg and bomb run stages were further subdivided into component tasks. Performance on each stage and component task was rated using a three-point scale (Satisfactory-Marginal-Unsatisfactory). Explanatory comments were required for all marginal and unsatisfactory ratings. Bomb scores and estimated bomb release parameters were recorded for each delivery. Pilot performance was assessed and recorded by IPs at the debriefing of each mission. Performance ratings were collected on all deliveries performed by the subject pilots throughout the GA phase.

Results and Discussion

An overall composite rating of each pass was generated from the ratings of the five individual stages occurring prior to weapons release. The relationship between the composite rating score and bomb score was assessed by a χ^2 contingency analysis. The composite rating score was found to vary directly with

bomb score (χ^2 = 198.3, P < .001; C = .5). These results demonstrate the validity of the rating methodology by relating the ratings to the best available objective measure of the quality of a delivery (i.e., bomb score). The pilots' progress over the course of training was expected to improve over the course of the GA phase, and the data supported this expectation.

Chi-square contingency analyses were performed on the ratings of the individual stages to determine the strength of their relationship to bombing accuracy. The stages which were found to bear the strongest relationship to bomb scores were stage 4, pipper placement, and stage 5, bomb run. These results demonstrate that while the correct initial setup of the delivery is necessary, it is the final stages that are most critical to bombing accuracy.

The present research has supported the conclusion of Pierce, DeMaio, Eddowes, and Yates, 1979, that instructor pilot ratings can provide valid fine grain information about pilot performance.

REFERENCE

Pierce, B.J., DeMaio, J., Eddowes, E.E., & Yates, D. *Airborne performance measurement methodology application and validation: F-4 pop-up training evaluation.* AFHRL-TR-79-7, AD-A072 611. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, June 1979.

APPENDIX D: SUMMARY REPORT: LOW ALTITUDE TACTICAL FORMATION SELF-ASSESSMENT EVALUATION STUDY

DeMaio, J.C., & Eddowes, E.E. *Airborne performance measurement assessment: Low altitude tactical formation in two operating environments.* AFHRL-TR-79-44. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, February 1980.

Objective

A study was conducted to determine what areas of skills are required for successful low altitude tactical formation (LATF) flying. It also investigated how well routine flying prepared pilots for flying in a simulated high threat environment.

Approach

The study was begun by interviewing mission-ready pilots. Data from these interviews were used to construct a rating form for evaluation of low altitude tactical formation flying performance. The importance of pilot skills was inferred from a multiple regression analysis in which the rating of overall performance was predicted from performance on the various skills.

Background

The present research is a part of the first phase of the Air Force Skills Maintenance and Reacquisition Training research program (Project SMART). This effort is aimed at defining flying skills critical to mission readiness and developing procedures to assess these skills. Skill data will be used to aid in increasing the efficiency of the Air Force continuation training programs. The LATF was the second tactical flying task selected for study. Proficiency at this task is critical to mission readiness, and the task taps several areas of flying skill.

Specifics

The low altitude tactical formation performance evaluation form included eitht-point rating scales for evaluating performance on the following flying skills: visual lookout, maintaining position (own performance), maintaining position (element member's performance), Time on Target, distance off target, and overall performance. In addition, a rating of Familiarity with element member (eight-point scale) was included. Low altitude flying performance data were comfort level and three measures of minimum altitude capability (flying straight and level, over rough terrain, and in turns). These were given in feet above ground level.

Data were collected in two operating environments. Twenty-eight A-7 pilots of the 354 Tactical Fighter Squadron at Davis-Monthan AFB provided self-rating data on their formation flying performance during routine operations. Twenty of these same pilots provided data on their performance in a simulated high-threat environment (Red Flag).

Data were analyzed via a step-wise linear multiple regression to determine which pilot performance variables were important to pilots' ratings of their overall formation flying performance. Variables examined were related to (a) the mutual support role of members of the formation in defending the

formation from attack, (b) low altitude flying performance, and (c) navigation performance. Four variables were found to provide a reliable index of overall individual LATF performance (R = .92) in the routine operating environment. These were (a) visual lookout, clearing the area for threats, (b) maintaining position in the formation (own performance), (c) maintaining position in the formation (element member's performance), and (d) familiarity with element member. The first two variables were felt to be directly related to the integrity and survivability of the formation. The last two variables, which *did not reflect* the individual's own performance, were felt to be important in determining pilot workload.

The regression analysis of performance in the high-threat environment revealed important differences from the routine operating environment. In particular, the importance of visual lookout increased by 60%. Familiarity with element member ceased to be important in the high-threat environment. This was interpreted to reflect a lack of consistency in pilot behavior in the routine and high-threat environments.

Conclusions

1. Pilot performance self-rating methodology was successfully applied to the low altitude tactical formation task. Pilot performance ratings were found to have high consistency.

2. Skill areas found to be important to the quality of an individual's formation performance were related to the mutual support role of the formation. Specific skill areas were (a) visual lookout, clearing the area for threats and (b) maintaining position in the formation.

3. An individual's performance rating was found to be affected by the other member of his element. An individual's performance rating increased when his rating of his element member's performance improved. Also, individuals rated their performance higher when they flew with a familiar element member.

4. When placed in a simulated combat environment, pilots were found to experience a period of reorientation and atypical behavior similar to that reportedly experienced in the actual combat situation.

APPENDIX E: SUMMARY REPORT: TAC-WIDE TEST

Lyon, D.R., Eubanks, J.L., Killion, T.H., Nullmeyer, R.T., & Eddowes, E.E. *Pop-up weapon-delivery maneuver: Use of pilot self-assessment data in analysis of critical components.* AFHRL-TR-80-33. Williams AFB, AZ: Operations Training Division, Air Force Human Resources Laboratory, October 1980.

Objective

At the request of Tactical Air Command Headquarters, a test of an aircrew self-report methodology for isolating the critical components of complex skills was conducted at mission-ready F-4 squadron across the United States. This methodology was being explored for possible use by the Air Force Skill Maintenance and Reacquisition Training Program (Project SMART), which had the goal of defining and measuring the most critical skills supporting aircrew mission readiness. The pop-up weapon-delivery maneuver was chosen as one of the test cases for determining the usefulness of the methodology.

Approach

Aircrews provided structured assessments of their performance on scored pop-up weapon deliveries in the following manner. The maneuver was subdivided into eight pre-delivery components and the parameters which define excellent, satisfactory, marginal, and unsatisfactory performance on each were given to aircrews after each delivery. Aircrews rated their performance on each component of the delivery and listed errors which caused less than satisfactory performance. Researchers stressed that this information would not be used for evaluating individuals or squadrons.

Several analyses were performed on assessments and listed errors, in order to determine the relative contribution of each component to delivery accuracy.

Specifics

Pilots and Weapons Systems Officers (WSO) from nine operational F-4 squadrons participated in the study. Squadrons participating were those of the 474th Tactical Fighter Wing (TFW) at Nellis AFB, the 347th TFW of Moody AFB, and the 4th TFW at Seymour Johnson AFB. Performance assessments were gathered during a 1-month period at each squadron, and in all, data were obtained for 545 deliveries. The following analyses were performed on these data:

1. Component assessments and weapon delivery accuracy category were cross-classified. Separate analyses were performed for different delivery events and for pilot and WSO data.

2. The strength of the relationship between performance assessments on each delivery component and delivery accuracy was determined. The obtained pattern of relationships was analyzed further to evaluate several hypotheses about its cause.

3. Reported delivery errors were also partitioned according to the delivery component on which they occurred. Conditional probabilities of a failed delivery, given that an error was reported, were computed for different parts of the delivery.

Results

The major result of the analysis of both the rating data and the reported error data was that the final two components of the delivery (track point and bomb run) showed by far the strongest relationships to delivery accuracy. This was true for all delivery events examined and for both pilot and WSO data. No consistent relationships between earlier delivery components and accuracy were found.

This result was apparently not a consequence of a cumulation of errors in earlier components leading to predictive track point and bomb run performance. The evidence for this is that the track point and bomb run performance remain predictive of accuracy for a subset of the data in which all earlier components received satisfactory or excellent ratings. Further analyses showed that:

1. Track point and bomb run ratings are not independent predictors of accuracy. For example, the partial correlation between the track point ratings and accuracy, with the bomb run ratings held constant, is non-significant.

2. Two potential indices of component difficulty, proportion of marginal and unsatisfactory ratings and number of reported errors, suggest the tract point and bomb run are the most difficult parts of the maneuver for these experienced crews.

3. The most frequent error reported for track point and bomb run components was failure to correct adequately for wind.

It should be noted the results apply only to experienced aircrews on training ranges, where navigation problems are minimal.

Conclusions

The results suggest that experienced aircrews can execute the initial parts of the pop-up maneuver well enough that errors in this portion of the maneuver do not greatly affect bomb scores. For these pilots, most of the value of pop-up training drills may consist of the opportunity to practice the final seconds of the maneuver.

The overall evaluation of this methodology is that, while it is clearly no substitute for direct measures of components of performance when available, it can nevertheless yield useful results. Some difficulties with use of self-assessment were surmountable when ratings of components were obtained.

☆U.S. GOVERNMENT PRINTING OFFICE: 1981- 771-055/120


DA
FILM